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Original Article

THE MECHANICAL CHARACTERIZATION OF MONO AND HYBRID FIBER REINFORCED COMPOSITES USING EXPERIMENTAL AND FINITE ELEMENT ANALYSIS METHODS

C. M. MEENAKSHI[1] & A. KRISHNAMOORTHY[2]

[1]*Assistant Professor, Department of Mechanical Engineering, Bharath Institute of Higher Education and Research, Chennai, Tamil Nadu, India*

[2]*Professor, Department of Mechanical Engineering, Sathyabama Institute of Science and Technology, Chennai, Tamil Nadu, India*

ABSTRACT

Fiber reinforced composites plays a major role in service sector and engineering field. This creates interest for the researchers towards natural fibers as reinforcement which is already a highly used reinforcement material in many of the non-structural applications. These materials are tailor-made materials with a different volume fraction of resin and fibers and the stacking sequence could be made unique for each application depends on the strength requirement. Therefore, whenever engineers try to use a new configuration the proposed laminate has to be tested for its mechanical performance, experimental testing of each new laminates is a time consuming and expensive process. This work is aimed at the comparison of mechanical performances of natural fiber, glass fiber and hybrid fibers reinforced with polyester resin. The laminates are prepared with flax and glass and also glass/flax hybrid fibers, their mechanical properties like tensile strength and flexural strength are experimentally tested and also analytically achieved using Finite element Analysis Method (ANSYS 16.2). All the tests are carried out on standard ASTM sized samples. The comparison shows analytical results are better than the experimental results and there is a deviation of 0.5 to 25% in the results between the two methods of testing.

KEYWORDS: Fiber Reinforced Laminates, Mechanical Properties, Experimental & FEA Method

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Nomenclature

GFRP-Glass Fiber Reinforced Polyester

NFRP- Natural Fiber Reinforced Polyester

HFRP- Hybrid Fiber Reinforced Polyester

INTRODUCTION

Researcher's attention has turned towards biodegradable materials in structural application owing to the continuous increase in awareness regarding biodegradability and government involvement in environmental safety [1]. Asian researchers are showing interest on natural fiber reinforced plastics, due to their low density which is one of the important factors of consideration in the automobile and aerospace industry. Lot of research works are going on in this regards, Maries Idicula Kuruvilla Joseph, Sabu Thomas [2] says that hybridization of fibers in polyester

composites results in a positive effect on tensile and flexural properties. Darshill U. Shah, Peter J. Schubel, Mike Clifford [3] found that flax is a suitable structural replacement to E-glass for small wind turbine blade applications.

Mohinisaxena[4] after done many reviews identify that plant based fibers are good replacement for synthetic based fiber in terms of cost, density, renewability and co_2 emission. C. W. Nguong, S. N. B. Lee, and D. Sujan[5] found that addition of Nano materials such as Nano Silica Carbide (n-SiC) and Nano Clay to natural fiber reinforced polymer composite will overcome the water absorption problemB. Vijaya Ramanathan[6] found that the banana and jute Hybrid composite is showing a good performance which is an evidence that the natural fiber hybrid composite as a promising material. With all this background it is understood that natural fiber reinforced composite is definitely a good member to recommend for structural application.

This paper is also going to explain one such work on natural fiber composites, flax from the family of jute one of the oldest types of fiber highly used in textile industry along with glass fiber and polyester resin are taken and laminates are prepared by hand layup method with different fiber combination. Their tensile, impact and flexural strength are computed experimentally and using the Finite element analysis (ANSYS 16.2) and compared.

EXPERIMENTATION AND RESULTS [7]

The Experimental testing has been done on sample prepared as per ASTM standard, for preparing the samples initially laminates were fabricated by hand lay-up method using E-glass and Flax fiber mats of 300 x 300mm sizes. The polyester resin and Hardener are mixed in the ratio of 10:1, the thinner is applied and required amount of polyester resin is applied on the mold the fiber mats are arranged in the required order, uniform and homogeneous composite laminate of 300x300x3 mm were prepared. Three types of laminates were prepared one with glass fiber other with natural fibers (Flax fibers) and the third with Glass/Flax hybrid fibers.

Experimental Testing

The Tensile and Flexural Test were performed on ASTM sized samples cut from the laminates using Water Jet cutting according to ASTM standards D-638 as in Figure 1 for tensile testing and in flat shape accordance with ASTM standards D-790 as in Figure 2 for flexural testing. The test was carried out on Universal testing machine with maximum capacity 600 KN, FIE Pvt Ltd Make.[7]

Figure 1: Tensile Test Specimen and Machine Setup [7]

Figure 2: Flexural Test Specimen and Machine Setup[7]

The overall mechanical performance of the GFRP, HFRP, NFRP are as in Table 1**.**

Table 1: Over all Mechanical Performance of Different Composite Laminate

S. NO	Composite Type	Tensile Strength (N/mm2)	Flexural Strength (N/mm2)
1.	GFRP	92.57	125.54
2.	HFRP	83.753	83.75
3.	NFRP	44.68	61.49

FINITE ELEMENT ANALYSIS

Finite element Analysis is an advancement of engineering analysis which will give accurate result. In this work the experimental results obtained are compared with the FEA results to find out the percentage of deviation between the two if it is less instead of doing experimental study all the time the researchers can opt for FEA study which is less time consuming and economical. Already, researchers were started using the FEA method for validating their composite material experimental result[8]. For analyzing the composite specimen the specimen model, engineering data and materials properties are mandate. The draft of the model created and the properties used are given in Figure 3 and Table 2. For finite element analysis purpose, the material is consider as isotropic all the properties like density, modulus and poisson's ratio are calculate using composite mechanics formulas and the boundary condition and load conditions are as same as experimental condition.

Table 2: Input Table for ANSYS

S. No.	Sample	Density, ρ (gm/cm3)	Young's Modulus, (GPa)		Poisson's Ratio, U	Force Applied	
			E_L	E_T		F (kN)	P (kN)
1.	GFRP	1.54	23.42	3.6576	0.2649	3.450	0.0783
2.	HFRP	1.43	23.22	3.6571	0.2629	2.490	0.0523
3.	NFRP	1.21	22.82	3.6560	0.3040	1.960	0.0384

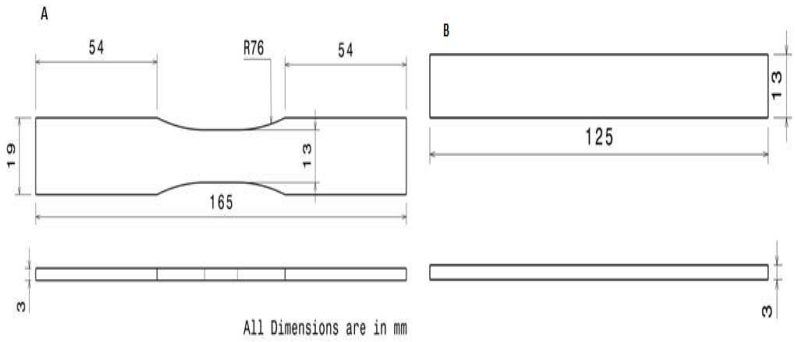

Figure 3: (a) Tensile Test Specimen (ASTM D-638) (b) Flexural Test Specimen (ASTM D-790)

The analyzed result of tensile and flexural deformation and stress of the composite materials are given in Figure 4 to Figure 9 all the results obtain are with the same loading and boundary condition as in case of experimentation work. The values of tensile and flexural strength are shown in Table 3

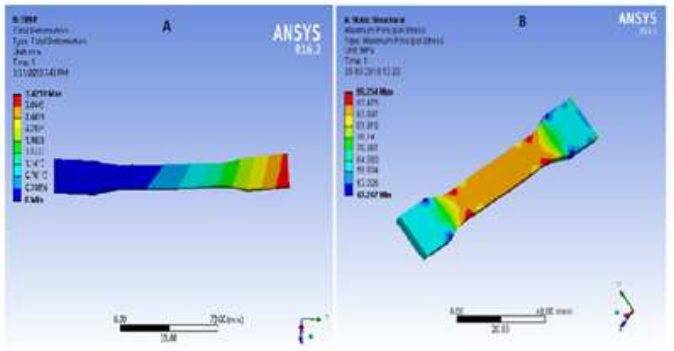

Figure 4: (a) Tensile Displacement in GFRP Sample (b) Tensile Stress in GFRP Sample

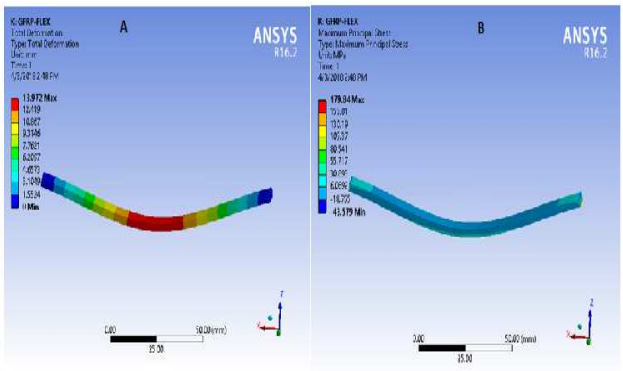

Figure 5: (a) Flexural Displacement in GFRP Sample (b) Flexural Stress in GFRP Sample

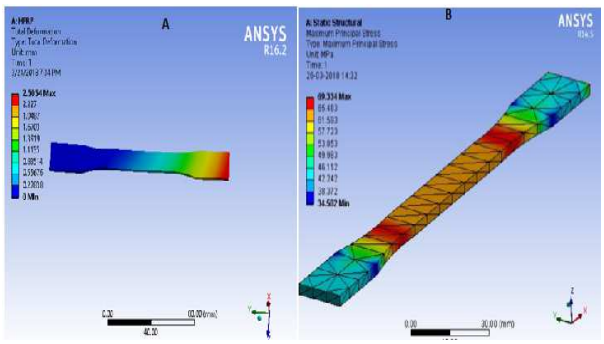

Figure 6: (a) Tensile Displacements in HFRP (b) Sample Tensile Stress in HFRP Sample

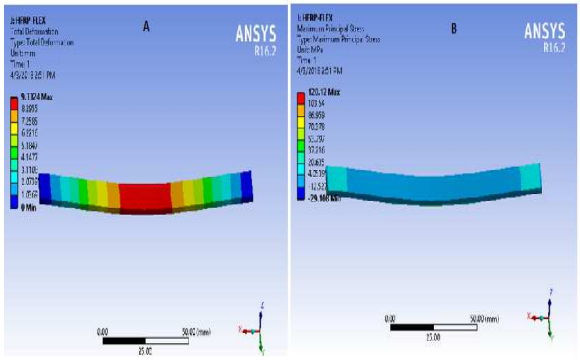

Figure 7: (a) Flexural Displacements in HFRP Sample (b) Flexural Stress in HFRP Sample

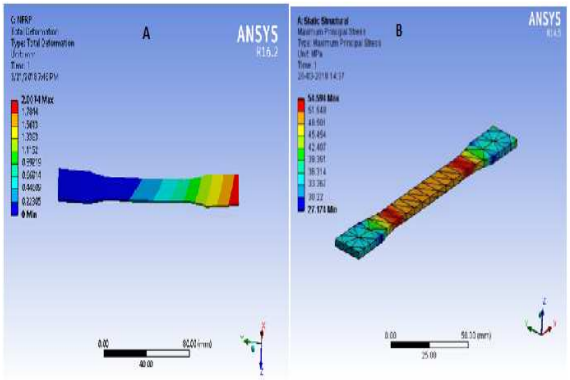

Figure 8: (a) Tensile Displacement in NFRP Sample (b) Tensile Stress in NFRP Sample

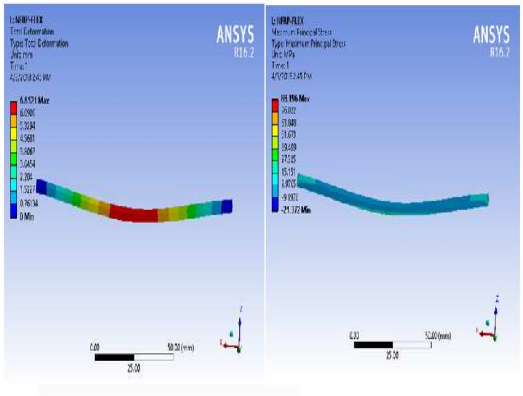

Figure 9: (a) Flexural Displacement in NFRP Sample (b) Flexural Stress in NFRP Sample

Table 3: Analytical Value of Tensile and Flexural Strength from ANSYS

S. No	Composite Type	Tensile Displacement mm	Tensile Strength N/mm2	Flexural Displacement Mm	Flexural Strength N/mm2
1	GFRP	3.43	99.254	13.97	179.84
2	HFRP	2.51	69.334	9.33	120.12
3	NFRP	2.01	54.594	6.85	88.19

COMPARISON OF RESULTS

The results obtained experimentally were compared with the simulation result in ANSYS software. The Comparisons of tensile stress values are as shown in Table 4 and Table 5 shows the comparison of flexural stress value. Results revealed that Analytical results are better than experimental results as shown in Figure 10 and Figure 11. These deviations of results occurred due to manufacturing defects of composites like voids and human influence on testing procedure etc. The overall comparison shows that the order of performance among the three composites is same as GFRP, HFRP and NFRP in both methods of analysis.

Table 4: Comparison of Experimental and ANSYS Tensile Strength Result

Type of Composite	Experimental Reference Values	FEA Analysis Using ANSYS	Percentage Error, %
GFRP	92.6	99.254	6.7
HFRP	66.8	69.334	3.65
NFRP	44.7	54.594	18.12

Table 5: Comparison of Experimental and ANSYS Flexural Strength Result

Type of Composite	Experimental Reference Values	FEA Analysis Using ANSYS	Percentage Error, %
GFRP	133.58	179.84	25.7
HFRP	87.35	120.12	27.2
NFRP	73.25	88.19	16.9

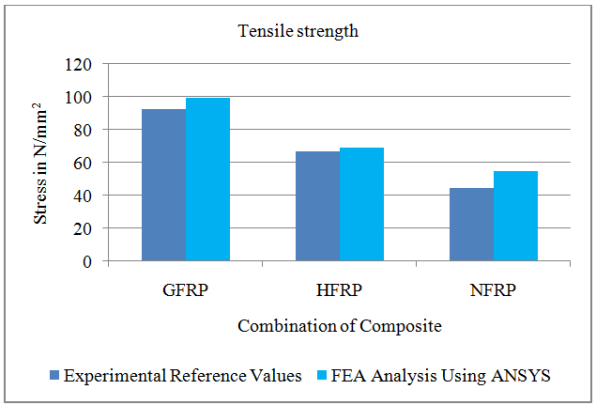

Figure 10: Comparison of Tensile Strength of GFRP, NFRP and HFRP by Experimental and Analytical Method

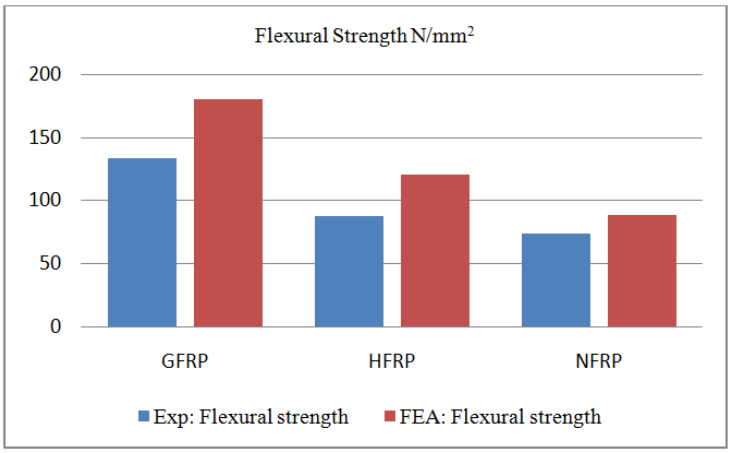

Figure 10: Comparison of Flexural Strength of GFRP, NFRP and HFRP by Experimental and Analytical Method

CONCLUSIONS

This research work is carried out to find out whether the analytical method could be used to find the mechanical properties of the laminate composites and the following conclusions are made.

- The comparison between two methods of study shows that there is a variation of 0.5% to 25% in the results.
- Irrespective of the variation, the order achieved in both the methods is same i. e. the performance ranking among the three laminates are same in both methods.
- Hybrid composites are showing promisingly good performance to glass fiber reinforced composite in tensile strength.

- Analytical results are better than the experimental results and the experimental results can be improved by adopting a better manufacturing process.

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